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ABSTRACT

A case study explores the importance of the educational setting and its affect on student learning, performance, attitude, and behavior. The study focuses on the facilities planner's perspective and raises important questions needing further study. Among the study's findings are the importance of timing in a school district's renovation projects, and a demonstrated positive relationship between upgraded school facilities and math achievement. Thoughts on facility/student relationship research needs and design conclude the article. (Contains 14 references.) (GR)

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SCHOOL BUILDING RENOVATION AND STUDENT PERFORMANCE:

One District's Experience

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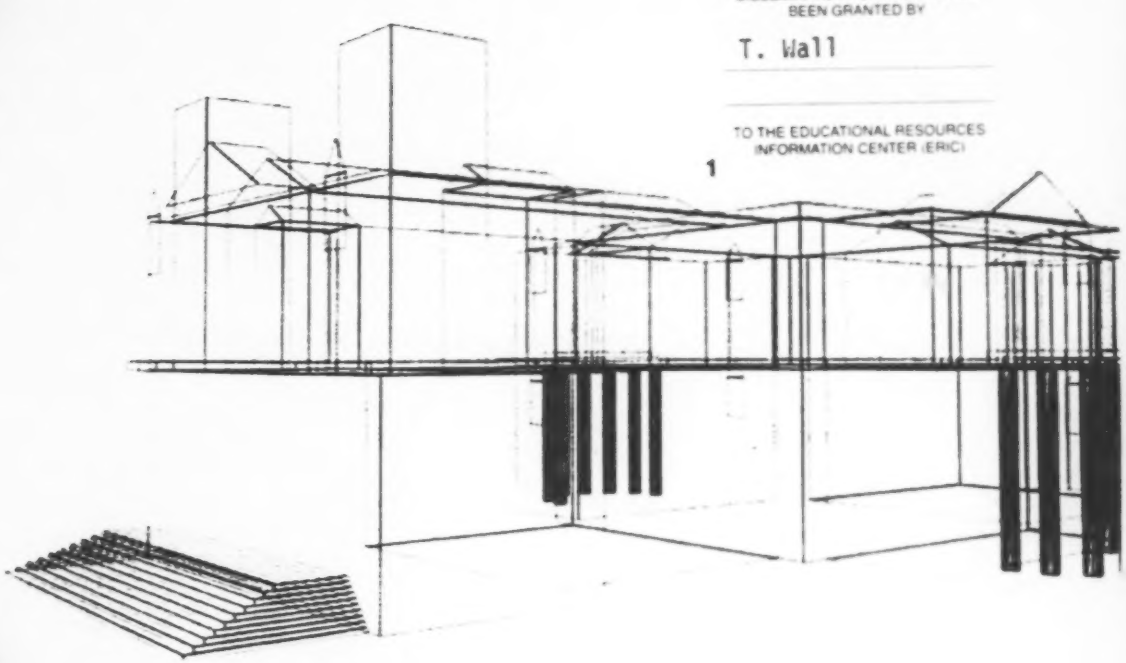

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Background

A good deal of attention has been given to the question of whether a student's learning and academic performance is affected by the condition of the school facilities and other physical environmental attributes. Earthman and Lemasters (1997) reviewed a number of studies related to the topic and cite a number of other researchers including Weinstein (1979) and McGuffey (1982) as useful resources for a broad view of relevant research.

Weinstein (1979) examines studies dealing with various environmental factors in educational settings for preschoolers through college, including class size, furniture arrangement and seating, density and crowding, and noise. Although this review is somewhat dated, it provides a wealth of information about the relation of physical environmental factors in school settings to student achievement and behavior. Weinstein's treatment of methodological concerns and historical perspective is also valuable.

Some of Weinstein's findings are valuable to planning and design professionals as well as educators. For example, classroom design, or furniture arrangement, can influence students' behavior (movement patterns, purposefulness, persistence, and involvement) and their attitude toward the class and other students. Teacher effectiveness may also be influenced by classroom design because of mismatches between design and teacher philosophy. Most of the density and crowding studies that Weinstein cites are either laboratory studies or field studies in preschool classrooms. The laboratory studies seem to indicate that high density does not affect task performance. However, critics of these studies point out that the lack of effects may be due to 1) the tasks used in the studies were not complex in terms of information-processing demands, and 2) the tasks performed in high-density settings did not require physical interaction or cooperation between individuals. Classroom density, however, has been found to have an effect on student behavior and attitudes; high classroom density is associated with increased aggression, decreased social integration, and dissatisfaction.

Noise is another major environmental factor studied by researchers. Weinstein reports that researchers have generally found little negative effects on student performance for short-term exposure to excessive noise. However, negative effects have been found for long term exposure. Lower reading scores are associated with exposure to high chronic noise from external sources such as airport, train, or truck traffic. In addition, children exposed to chronic noise exhibit greater distractibility with increased years of exposure, show a lack of task persistence, and have significantly higher blood pressure levels than children in quieter settings. More recent research not included in Weinstein's review indicates that noise exposed elementary school children, when compared to peers in quieter schools, have lower reading scores and have poorer language acquisition skills (Evans & Maxwell, 1997). When external noise sources such as airport traffic are removed and children are re-tested in quiet conditions, the effects of noise exposure remain even after removal from the noise source. This team of researchers also found that an internal noise source, such as poor acoustical design, resulted in decreased language use and language acquisition skills, and lower scores on a pre-reading measure for preschool age children (Maxwell & Evans, in press). Clearly long-term exposure to noise is problematic for children in terms of cognitive and motivational factors.

Moore and Lackney (1993) reviewed a number of studies from which they propose several recommendations for school design. One of their key conclusions is that smaller schools (total enrollments around 500-600 students) provide better educational outcomes than do larger schools (over 1000 students).

In smaller schools more students have a higher level of involvement with extracurricular activities and exercise more leadership roles in the school (Barker & Gump, 1964). More positive involvement with the school is seen as a mediating variable whereby if students have more interest in the school and benefit from higher self-esteem due to more responsibilities, learning will also be improved and students' academic performance will be positively affected. Smaller schools are especially effective in improving academic performance for students in inner city schools.

Moore and Lackney also note the long-term effects of class size on academic performance. In a study of 6500 students conducted in Tennessee, the STAR Project, students in small class sizes (13-17 children) outperformed their peers in larger classes (22-25 children) on the Stanford Achievement test. The benefits of smaller class sizes were especially helpful for children in

inner city schools (Achilles et al., 1990). In a follow-up study it was found that students who were in the small classes in first through third grade continued to outperform their peers in the larger classes when each group moved to the fourth grade and were in larger classes (25 children). These findings were consistent across rural, urban, inner city, and suburban schools.

Since small social groupings of students seems to improve the academic performance of elementary school students, Moore and Lackney recommend the redesign of the typical classroom to allow for smaller groupings of students in classes that may have 20-30 students. They advocate for creating Well-defined Activity Pockets that are smaller, partitioned divisions within the classroom. This arrangement has been shown to increase engagement with learning activities and to reduce interruptions. Additional research, however, is needed to determine the effects on performance.

Case study

From the above review we can conclude that indeed physical attributes of the educational setting can affect student learning, performance, attitude, and behavior. All of the attributes are, to varying degrees, within the control of the educational facility planner and designer. The following study, conducted in cooperation with the Syracuse, New York, City School District (SCSD) focuses on the facilities planner's perspective and raises important questions needing further investigation. Much of past research makes comparisons between students in different settings. Research on the before-and-after effects of improving the quality of facilities has been relatively sparse. In such situations the staff is often a constant, while comparing students from different schools means that the teaching styles are also a factor. We used data on student performance from before, during, and after the renovation of several school buildings in Syracuse, New York. This methodology sheds light on issues that a "good-buildings vs. bad-buildings" study does not.

The Syracuse City School District made an interesting case study. The city is fairly homogenous in terms of income. The boundaries of the city proper are the borders of the school district as well, thus limiting large disparities in student types across schools. The district also allows students to choose which school they attend for the year, regardless of distance from home to school. During the study period, each year approximately half of the student body in each school was new to the school. Furthermore, the increase in enrollment that accompanied the expansion of the schools under study naturally led to an influx of new students. Because of the dynamic nature of the student body it makes it difficult to draw conclusions about student improvement in a particular school from year to year. For Syracuse as a whole, however, students new to the district accounted for only about ten

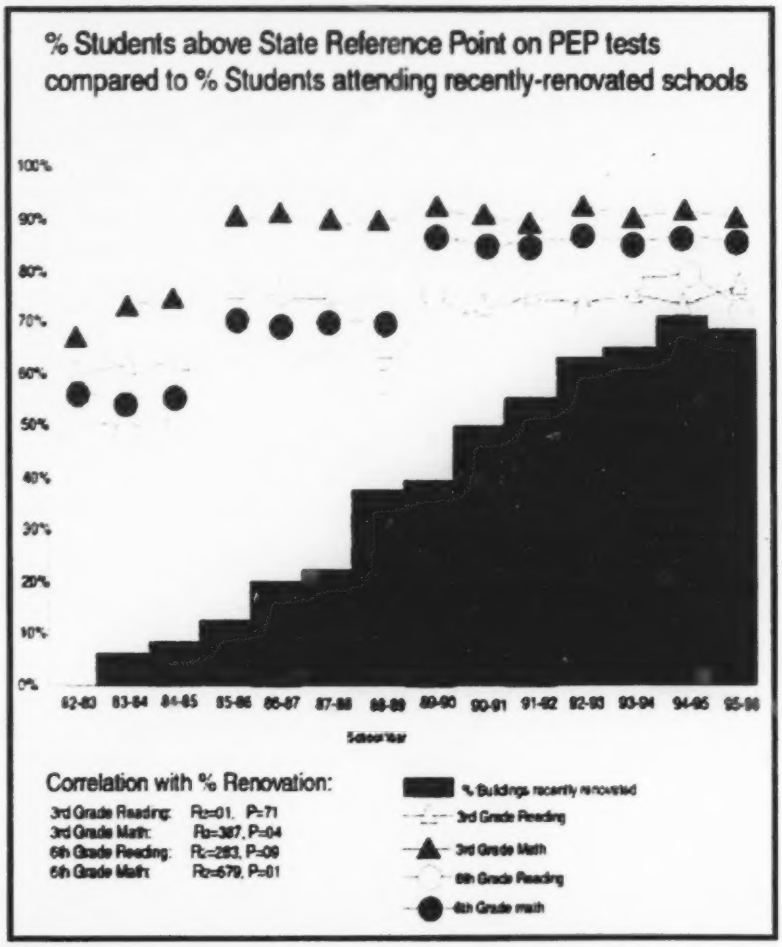

figure 1

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percent of the student body. Therefore our observations at the district-wide level have a much more stable base of students.

New York State evaluates its third-and sixth-grade students in math and reading statewide annually via the Pupil Evaluation Program (PEP) test. This provides a convenient, time-tested, and well-documented means of measuring student achievement in these areas. The PEP test is primarily used as an early warning tool to identify students who are performing below par. The published figure reports the percentage of students in a school that score at or above the state-determined minimum reference score. A high-percentage figure indicates that the bulk of children are doing well while a lower number suggests that more students are at risk for poor school performance. The PEP test is administered each May.

Figure 1 (on page 4) compares district-wide PEP test scores across several years to the percentage of students in the district attending recently renovated schools. "Recently-renovated" is defined as a major renovation within the past ten years. A positive correlation between the two measures would provide "big picture" evidence that renovation improves student learning. Before 1984, none of the schools in the district had seen significant facility improvements for some time. 1984 marked the beginning of a spurt in renovation work throughout the school district. The number of students attending renovated schools grew to over 10,000 in 1994 (total enrollment in the Syracuse district hovers around 20,000). Using regression analysis, of the four student performance measures (third- and sixth-grade reading and math PEP scores), only the math scores showed a statistically significant correlation with the percentage of students attending recently-renovated schools (see figure 1). All of the twenty-one elementary schools were included in the analysis. Taken at face value, this finding raises several questions: 1) Why might the quality of facilities affect math learning more than reading? 2) Might there be a difference in the way children learn math skills versus reading skills? 3) Why is the relationship especially strong for older students (6th grade vs. 3rd grade)?

One explanation for these findings might be that there was an influx of students for whom English was a second language (ESL). This might explain why reading scores did not improve as significantly as the math scores — there has been an increase in the per-

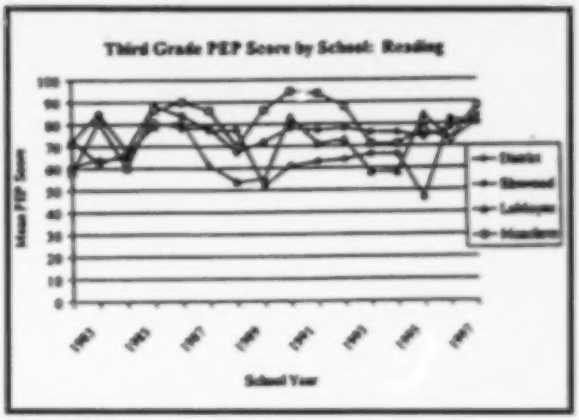

figure 2

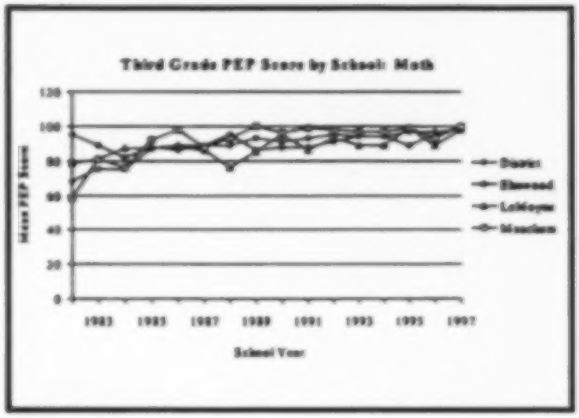

figure 3

centage of students who have limited proficiency in English. If it were possible to separate out the ESL students from the rest of the school population, a more in-depth analysis of the PEP data might prove or disprove this hypothesis. Another explanation might be that the way math was taught changed: SCSD Central office administration indicates that there was no system-wide change in math instruction. Still another explanation might be that math scores are more sensitive to intervention than reading scores. Of course it is possible that the improvement in school facilities had little to do with the improved math scores. The findings in this study has established a relation between newer facilities and math scores, but causation has not been established. Further study with tighter controls will be required to determine causation.

The research team took a closer look at three schools, LeMoyne, Meachem, and Elmwood, to get a better idea of the nature and scope of renovation. The three

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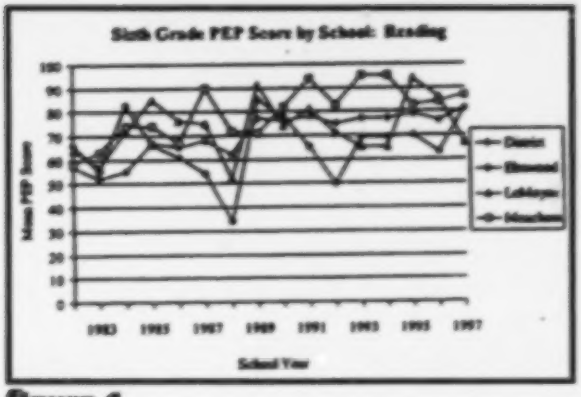


figure 4

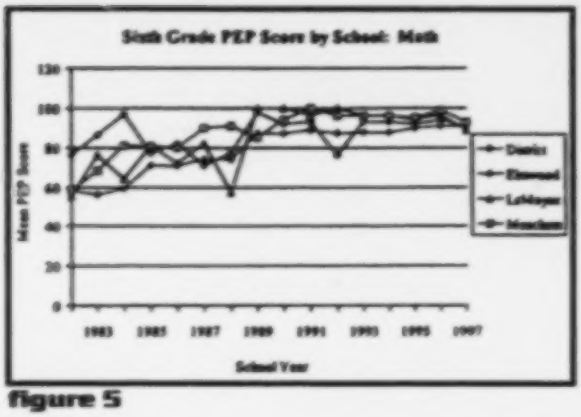


figure 5

buildings had some key similarities. They are all K-6 schools, and all were originally built within fourteen years of each other (1914-1928) with approximately the same square footage in floor space (64,200 to 72,666 sq. ft.). In fact, two of the schools – LeMoyne and Meachem – shared the same design and were built by the same architectural firm, so they were (before renovation) essentially identical. The renovations resulted in roughly equal increases in square footage for about the same costs – on the order of five to six million dollars.

The results of the PEP test were plotted for the five years before the renovations to five years after. This meant eleven years (in some cases, twelve years) of test results, bisected by the period of renovation. For the three schools in question, renovations began after classes ended for the summer in 1987. Work continued through the 1987-88 school year, and the finishing touches were completed during the early months of the following school year (September- November, 1988). The data set from the three schools is not large enough to obtain statistically significant results. However, a visual observation of the data suggests some trends. Graphing the math test scores across time depicts a clear upward trend in all three schools. The reading scores, on the other hand, fluctuated widely from year to year and from school to school with no apparent trend – reflecting once again the curious difference in effect on reading and math performance. (see figures 2,3,4,& 5)

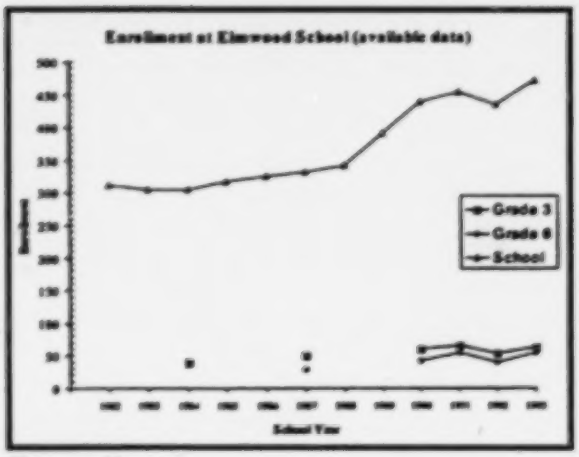
There were common elements to each of the school's renovations—floors and walls throughout the buildings were refinished, kitchens were completely overhauled, incandescent lighting was replaced by fluorescent, and new blackboards were installed. Elmwood and LeMoyne each expanded by 24,000 square feet; Meachem grew by 30,000 square feet. The planning process at each school included extensive participation by community members, school administrators, and parents. Meetings were held on roughly a weekly basis for almost a year. Each committee had wants and needs particular to their building. For example, LeMoyne school had old wood floors in the school that they wanted to refinish, over which carpet was placed. LeMoyne focused on energy conservation and lighting conditions – the school's fluorescent lighting was supplemented by ultra-violet light-emitting lamps in the belief that it would be beneficial to children. A recent study indicates that supplemental ultraviolet lights in the classroom reduces dental problems in children by stimulating vitamin-D in the body (Hathaway, 1995). Large windows were installed as well to allow more daylight to enter the building. The bulk of renovation in Meachem and Elmwood was new classrooms, LeMoyne added a number of supplemental spaces, such as a speech room, a resource room, and faculty and parent areas.

The average class size for the schools did not vary greatly over the study period. The average class size for the district ranged between 23 and 27 students. The average for schools in the study ranged from 20 to 27. Previous research (Moore & Lackney, 1993) suggests that student performance is not affected by this range in variation of class size; changes are noted once class size drops below 18 or 17 students. Overall enrollment numbers at the schools fluctuated during the study period. As intended, the expansion of the schools was accompanied by increases in enrollment because classroom space was added. Total

enrollment (K-6) for two of the schools during the study period ranged from the mid-300's before renovation, growing to the mid-400's afterwards. Meachem was the exception – it saw a marked increase in enrollment, going from a stable enrolment of around 400 for the five years before renovation, growing quickly in subsequent years to reach 664 students in 1993. Each school remained in, or close to, the small school range of 500-600 students. The number of classrooms almost doubled, going from 12 to 23. This trend plays out similarly in the enrollment numbers for individual grade-levels: third-grade enrolment at Meachem almost doubled from the pre- to post-renovation period (from 49 in 1987 to around 100 in 1992 and 1993). Sixth-grade enrollment at all the schools except LeMoyne grew by more than twenty students. (see figures 6,7,& 8)

School administrators felt that the students' environment suffered during the actual construction period. Some of the schools arguably saw a decline in student performance during this period. Students were exposed to dust, noise and the presence of workers and machinery. This has critical implications on schools that are planning renovations. School administrators can easily see the positive effects to be gained from renovation but may fail to recognize the costs to the learning process incurred by the renovation period itself.

The Syracuse School District made attempts to relocate a portion of students away from the construction site, both to protect them from the detriments of construction as well as to make room for the renovations. Meachem and LeMoyne, for example, placed their first grade classes in purpose-built trailers for the duration of the renovation time. Unfortunately since first graders do not participate in the PEP testing there is no way determine if this alternative was effective in reducing the ill effects of exposure to the renovation process. In another situation (not one of the study schools) the entire student body was relocated to a nearby Catholic school building for the school year. Facilities planners in Syracuse claim that this strategy prevented a drop in student performance; however, data is not available to substantiate the claim. Future research should include these alternatives in the hypothesis testing.



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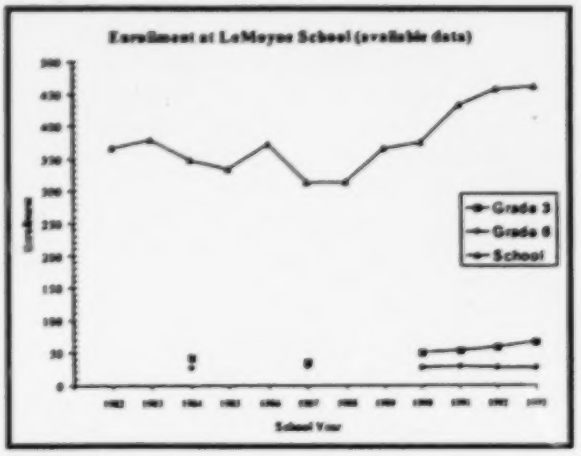

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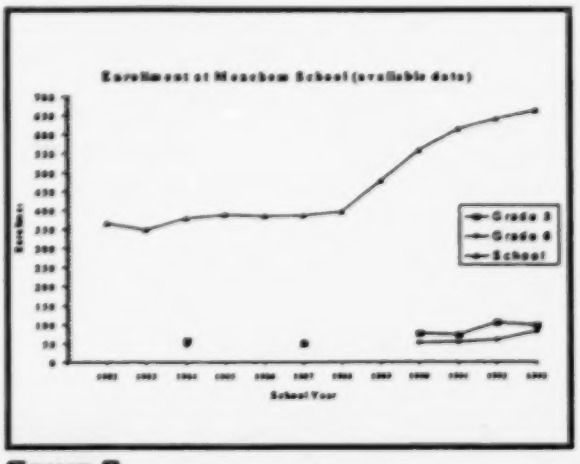

figure 8

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Certain indicators suggest that the City of Syracuse was experiencing a trend of overall decline during the study period. Students whose families meet the criteria for financial need received free lunch at school. The number of such students receiving free lunches is a rough indication of the proportion of low-income students at each school. The data on this measure before 1990 is spotty, but since 1990 all three schools in the case study saw an increase in the number of students receiving free lunches. The proportion of these students also increased markedly, suggesting it is more than just a matter of increasing enrollment. State educational aid to the district is another measure of the local capacity to support schools. The percentage of school building costs in Syracuse covered by New York State also increased sharply over the study period, indicating a downward trend in property values in the area. By conventional wisdom, then, Syracuse had good reason to see student performance fall. The gradual climb in scores despite this is encouraging support for the effect of facilities' quality on student performance. Perhaps improved facilities had a positive effect on student and teacher attitudes toward learning which resulted in improved test scores. Future research could investigate this hypothesis by including such variables as teacher turnover, teacher and student absenteeism, and number of student disciplinary actions. An improved physical environment affects the social climate of the school which subsequently has a positive effect on learning (Moos, 1979).

Another benefit of renovation is the increase in pride and participation on the part of parents. Schools whose PTA organizations were virtually non-existent beforehand saw parents take an interest in the goings-on at the school. In recent years with the introduction of computers, some schools began to give evening computer classes to parents. The schools became a true nexus for community interaction. In fact, the original impetus for making renovations – rather than constructing a new, larger school that would consolidate several schools' students into one building (which would have cost less than individual renovations) – was a public outcry in some communities against taking away "our school". This fits well with past research by Berner (1993) on schools in the District of Columbia. A positive correlation between parental involvement in the schools and the condition of the school buildings themselves was noted. Berner also notes a positive relationship between building condition and student achievement.

It should also be noted that elementary school-age children are aware of the physical attributes of a setting. David (1982) found that nine-year-old children were able to articulate features of classroom settings that either described their current classroom or their ideal classroom. The classroom features included items related to: 1) comfort – comfortable and orderly classroom; 2) autonomy – features that enhance children's ability to make choices; 3) opportunity – places for various activities (i.e., places to work, places for privacy); and 4) personal meaning – features in a classroom that affirms each child. Cohen and Trostle (1990) found that younger school-aged children (ages 5 to 7) were also able to express preferences for environmental stimuli in school settings. Children 9-11 years were more likely than adults (teachers and parents) to identify untidy classrooms, dirty bathrooms, and school walls painted only one color -white- as physical attributes that made their school not welcoming (Maxwell, in press). Since children are so keenly aware of their surroundings, planners, architects, educators, and taxpayers must consider what message is given to school children when school facilities are old and poorly maintained.

Conclusions

Based on the review of previous studies and the present case study, we can conclude that physical environmental attributes of school facilities play an important role in students' academic performance, attitudes, and behavior. While well-maintained and updated facilities are important, when school districts are faced with major renovations, the present study indicates that timing of the renovations is important. Subjecting students and teachers to the noise and confusion of a building undergoing major renovation may result in decreased student academic performance. While students seem to recover once the construction work is done, it is still a concern that administrators and facility planners should take into account when planning the construction schedule. It would be useful to investigate practical ways of avoiding detriment to the learning process while construction and renovation work is being done. Perhaps an obvious solution is to avoid doing the work while school is in session. Or, as was done in a few cases in Syracuse, move students to a temporary facility while renovations take place. Neither of these options, however, may be feasible for large-scale projects or in districts with few resources.

This study demonstrated a positive relationship between upgraded school facilities and math achievement. The sample, however, in this study was small even considering the entire Syracuse City School District. In addition, the study identified a correlation between improved academic performances and newer facilities. A larger sample and methodology that will help to determine causation is the next step in this research agenda. The sample should include schools in urban, suburban, and rural communities so that any potential differences can be determined. It is also important that a standardized achievement measure be available. New York State is fortunate that all students are assessed with the same instrument. In addition, if archival data is available on students that were relocated during renovation and their performance is compared to students remaining on site during renovation, the finding in the present study of a decrease in student performance during the renovation period can be further substantiated.

Future research might also consider including data on teacher and student turnover, absenteeism, and student disciplinary occurrences. Such research would permit the testing of a model stating that physical environmental features affect student and teacher attitudes and these attitudes towards learning and teaching are related to student achievement. Older students (middle and high school) should also be included in the sample to enhance the ability to generalize the findings. Future research should also establish which facility attributes are most effective in improving student learning in order to help districts with limited resources make decisions about how to use scare dollars. Other models might also be tested to establish causation.

This study is an important step in assessing the effect of the renovation of school facilities on student performance. Many districts are faced with convincing taxpayers that additional dollars are needed for facility improvements. Research of this type can therefore be useful to school administrators and local governments in making the case for additional funds for local school facilities. In addition, it points to the need to carefully look at what effects the renovation process itself may have on student performance.

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